Energy, power and resistance	**Power and electrical energy**

Learning objectives	**MUST (6)**	Recall the meaning of power
	SHOULD (7)	Derive and apply equations for power
	COULD (8/9)	Understand how domestic energy is charged and calculate costs of energy

STARTER:

A metal wire has a length l and a cross-sectional area A. When a potential difference V is applied to the wire, there is a current I in the wire.

What is the resistivity of the wire?

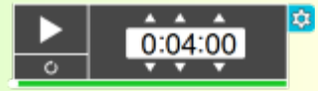
A $\frac{IA}{Vl}$

B $\frac{VA}{Il}$

C $\frac{Il}{VA}$

D $\frac{Vl}{IA}$

B



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Power is the rate of energy transfer, and is measured in watts (W).

Equation 1:

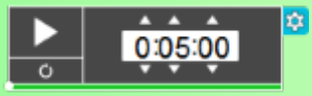
Power = potential difference x current $P = VI$

Think about what p.d. and current represent: can you explain why VI is equal to the rate of energy transfer?

volts = joules per coulomb

current = coulombs per second

so volts x current = joules per second



Equations 2 and 3:

We need to derive two other equations expressing P in terms of V, I and R. We have an equation without R, so now we need one without I and one without V. Use V = IR to derive them.

$$P = I^2R \qquad P = \frac{V^2}{R}$$

Power in a resistor will be dissipated as heat.

Extension: why does the National Grid transmit electricity at extremely high voltages?

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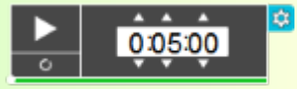
Energy, power and resistance	**Power**
COULD (8/9)	Understand how domestic power is charged and calculate costs of energy

We use the kWh (kilowatt hour) for energy billing: it means the amount of energy that would be used if a 1 kW appliance was used for an hour.

How many joules in 1 kWh? 3.6 million



Why do we use the kWh?

Energy (kWh) = power (kW) x time (hours)

A 500W appliance runs for 30 minutes. How many kWh?

Summary questions

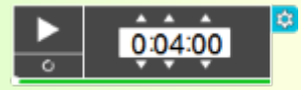
1 Using the appropriate circuit symbols outline a simple experiment that could be used to determine the power of a filament lamp (you should include a circuit diagram in your answer). *(2 marks)*

2 Calculate the rate of energy transfer from a resistor with a current of 5.0 A and a p.d. of 8.0 V. *(2 marks)*

3 A 1.2 kW heater has a p.d. of 20 V when working normally. Calculate:
- **a** the current in the heater; *(2 marks)*
- **b** the energy transferred in one hour. *(2 marks)*

4 State and explain the effect on the rate of energy transfer for a component when:
- **a** its resistance doubles (the current in the component remains unchanged);
- **b** the current in the component doubles (the resistance is unchanged). *(4 marks)*

5 Using base units, show that one watt is equivalent to one volt amp (1 W = 1 VA). *(4 marks)*



9.10

1 Circuit diagram with power supply/cell/battery, filament lamp in series with an ammeter. Voltmeter connected in parallel across lamp. [1]
Measure V and I and calculate power using $P = IV$. [1]

2 $P = IV$ [1]
$P = IV = 5.0 \times 8.0 = 40\,W$ [1]

3 **a** $P = IV$ therefore $I = \frac{P}{V}$ [1]
$I = \frac{1200}{20} = 60\ A$ [1]
b $P = \frac{W}{t}$ therefore $W = Pt$ [1]
$W = 1200 \times 3600 = 4.3\,MJ$ (2 s.f.) [1]

4 **a** $P = I^2R$ therefore at constant current $P \propto R$ [1]
If R doubles P doubles. [1]
b $P = I^2R$ therefore if the resistance remains unchanged $P \propto I^2$ [1]
If I doubles P increases by a factor of 4 (2^2). [1]

5 Find the watt in base units.
From $P = \frac{W}{t} \rightarrow$ [W] = [J s^{-1}]
From $W = Fx \rightarrow$ [J] = [N] × [m]
Therefore [W] = [N m s^{-1}]
From $F = ma \rightarrow$ [N] = [kg m s^{-2}]
Therefore the watt in base units is kg $m^2 s^{-3}$. [2]
Express V A in base units.

From $V = \frac{W}{Q} \rightarrow$ [V] = [J C^{-1}]
From $W = Fx \rightarrow$ [J] = [N] × [m]
Therefore [V] = [N m C^{-1}]
From $F = ma \rightarrow$ [N] = [kg m s^{-2}]
Therefore [V] = [kg $m^2 s^{-2}$ C^{-1}]
From $\Delta Q = I\Delta t \rightarrow$ [C] = [A s]
Therefore [V] = [kg $m^2 s^{-3}$ A^{-1}]
Therefore [V A] = [kg $m^2 s^{-3}$ A^{-1} A] = [kg $m^2 s^{-3}$] [2]

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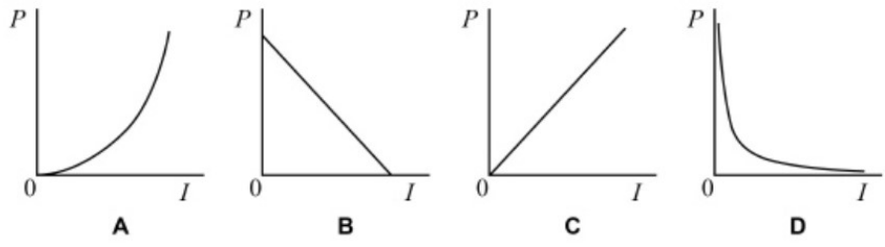
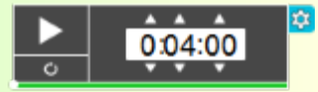
PLENARY:

Which graph shows how power dissipated P varies with current I in a component that obeys Ohm's law?



A



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